Table 12.1 - Renewable Energy Impacts Calculation

Conversion Formula:	*Step 1*	*Capacity (A) x Capacity Factor (B) x Annual Hours (C) = Annual Electricity Generation (D)*
	Step 2	*Annual Electricity Generation (D) / Competing Heat Rate (E) = Annual Output (F)*
	Step 3	*Annual Output (F) x Emissions Coefficient (G) = Annual Emissions Displaced (H)*

Technology	**Wind**	**Geothermal**	**Biomass**	**Hydropower**	**PV**
(A) Capacity (kW)	2,420,000	2,850,000	1,390,000	79,000,000	10,000
(B) Capacity Factor (%)	36.0%	90.0%	80.0%	51.6%	22.5%
(C) Annual Hours	8,760	8,760	8,760	8,760	8,760
(D) Annual Electricity Generation (kWh)	7,631,712,000	22,469,400,000	9,741,120,000	357,092,640,000	19,710,000
(E) Competing Heat Rate (Btu/kWh)	10,000	10,000	10,000	10,000	10,001
(F) Annual Output (Trillion Btu)	76	225	97	3,571	0
(G) Carbon Coefficient (MMTCB/Trillion Btu)	0.01783	0.01783	0.01783	0.01783	0.01783
(H) Annual Carbon Displaced (MMTC)	1.361	4.006	1.737	63.670	0.004

Sources: Capacity: EIA, Annual Energy Outlook 2002, Table A17, 2001.
Capacity Factors: Estimates based on DOE, Renewable Energy Technology Characterizations, 1997 and Program data
Carbon Emission Coefficient: DOE, GPRA2003 Data Call, Appendix B, page B-16, 2002.

Table 12.2 - Number of Home Electricity Needs Met Calculation

Conversion Formula: *Step 1* *Capacity (A) x Capacity Factor (B) x Annual Hours (C) = Annual Electricity Generation (D)*
Step 2 *Annual Electricity Generation (D) / Average Consumption (E) = Number of Households (F)*

Technology	**Wind**	**Geothermal**	**Biomass**	**Hydropower**	**PV**
(A) Capacity (kW)	2,420,000	2,850,000	1,390,000	79,000,000	10,000
(B) Capacity Factor (%)	36.0%	90.0%	80.0%	59.0%	22.5%
(C) Annual Hours	8,760	8,760	8,760	8,760	8,760
(D) Annual Electricity Generation (kWh)	7,631,712,000	22,469,400,000	9,741,120,000	408,303,600,000	19,710,000
(E) Average Annual Household Electricity Consumption (kWh)	10,582	10,583	10,584	10,585	10,586
(F) Number of Households	721,198	2,123,160	920,363	38,573,793	1,862

Sources: Capacity: EIA, Annual Energy Outlook 2002, Table A17, 2001
Capacity Factors: Estimates based on DOE, Renewable Energy Technology Characterizations, 1997 and Program data

Table 12.3 - Coal Displacement Calculation

Conversion Formula:	*Step 1*	*Capacity (A) x Capacity Factor (B) x Annual Hours (C) = Annual Electricity Generation (D)*
	Step 2	*Annual Electricity Generation (D) x Conversion Efficiency (E) = Total Output (F)*
	Step 3	*Total Output (F) / Fuel Heat Rate (G) = Quantity Fuel (H)*

Technology	**Wind**	**Geothermal**	**Biomass**	**Hydropower**	**PV**
(A) Capacity (kW)	2,420,000	2,850,000	1,390,000	79,000,000	10,000
(B) Capacity Factor (%)	36.0%	90.0%	80.0%	60.0%	22.5%
(C) Annual Hours	8760	8760	8760	8760	8760
(D) Annual Electricity Generation (kWh)	7,631,712,000	22,469,400,000	9,741,120,000	415,224,000,000	19,710,000
(E) Conversion Efficiency (Btu/kWh)	10,000	10,000	10,000	10,000	10,000
(F) Total Output (Btu)	76,317,120,000,000	224,694,000,000,000	97,411,200,000,000	4,152,240,000,000,000	197,100,000,000
(G) Coal Heat Rate (Btu per short ton)	20,525,000	20,525,000	20,525,000	20,525,000	20,525,000
(H) Coal (short tons)	3,718,252	10,947,333	4,745,978	202,301,583	9,603

Sources: Capacity: EIA, Annual Energy Outlook 2002, Table A17, 2001.
Capacity Factors: Estimates based on DOE, Renewable Energy Technology Characterizations, 1997 and Program data

Table 12.31 - National $S0_2$ and Heat Input Data

	1980	1985	1990	1999	2000	2010	2020
$S0_2$ (lbs)	34,596,164,000	32,184,330,000	31,466,762,000	24,904,614,200	22,404,284,000		
Heat (Btu)	17,859,931	18,414,434	19,684,248	24,928,629	25,598,096		
$S0_2$ Heat Factor (lb/Btu)	1937.1	1747.8	1598.6	999.0	875.2		

Source: EPA, *Acid Rain Program Compliance Report 2000, Emission Scorecard*, Table A1

Table 12.32 - SO_2, NOx, CO_2 Emission Factors for Coal Fired and Non-Coal Fired Title IV Affected Units

	1996	1999	2000	2010	2020
SO_2 (lbs/Btu)					
Coal	1,241	1,166	1,036		
Non-Coal	247	267	200		
Total	1,096	999	875		
NO_x (lbs/Btu)					
Coal	568	485	444		
Non-Coal	233	244	210		
Total	518	440	399		
CO_2 (lbs/Btu)					
Coal	206,139	205,586	205,646		
Non-Coal	132,978	132,001	133,094		
Total	195,521	191,956	191,678		

Source: EPA, Acid Rain Program Compliance Report 2000, Emission Scorecard, Table 1

Table 12.33 - Sulfur Dioxide, Nitrogen Oxide, and Carbon Dioxide Emission Factors, 1999

Fuel	Boiler Type/ Firing Configuration	Emission Factors: Sulfur Dioxide [1]	Nitrogen Oxides [2]	Carbon Dioxide [3]
Utility		lbs per ton	lbs per ton	lbs per 10^6 Btu
Coal and Other Solid Fuels				
Petroleum Coke[5]	fluidized bed[4]	39.0 x S	21	225.13
	all others	39.0 x S	21	225.13
Refuse	all types	3.9	5	199.82
Wood	all types	0.08	1.5	0
Petroleum and Other Liquid Fuels		lbs per 10^3 gal	lbs per 10^3 gal	lbs per 10^6 Btu
Resudual Oil[6]	tangential	157.0 x S	32	173.72
	vertical	157.0 x S	47	173.72
	all others	157.0 x S	47	173.72
Distillate Oil[6]	all types	157.0 x S	24	161.27
Propane (liquid)	all types	86.5	19	139.04
Natural Gas and Other Gaseous Fuels		lbs per 10^6 cf	lbs per 10^6 cf	lbs per 10^6 Btu
Natural Gas	tangential	0.6	170	116.38
	all others	0.6	280	116.38
Blast Furnance Gas	all types	950	280	116.38

Fuel	Boiler Type/ Firing Configuration	Emission Factors: Sulfur Dioxide [1]	Nitrogen Oxides [2]	Carbon Dioxide [3]
Nonutility		lbs per ton	lbs per ton	lbs per 10^6 Btu
Coal and Other Solid Fuels				
Liquid Waste	all types	2.8	2.3	163.29
Municipal Solid Waste	all types	1.7	5.9	189.48
Petroleum Coke[7]	all types	39.0 x S	14	225.13
Sludge, Sludge Wood/Waste	all types	2.8	5	0
Sulfur	all types	7	0	0
Waste Byproducts	all types	1.7	2.3	163.29
Wood/Wood Waste	all types	0.08	1.5	0
Petroleum and Other Liquid Fuels		lbs per 10^3 gal	lbs per 10^3 gal	lbs per 10^6 Btu
Heavy Oil[6]	all types	157.0 x S	47	173.72
Light Oil[6], Kerosene	all types	142.0 x S	20	159.41
Diesel	all types	142.0 x S	20	161.27
Butane (liquid)	all types	0.09	21	143.2
Oil Waste	all types	147.0 x S	19	163.61
Propane (liquid)	all types	0.5	19	139.04
Sludge Oil	all types	147.0 x S	19	0
Natural Gas and Other Gaseous Fuels		lbs per 10^6 cf	lbs per 10^6 cf	lbs per 10^6 Btu
Natural Gas	all types	0.6	280	116.97
Butane (gas)	all types	0.6	21	143.2
Propane (gas)	all types	0.6	19	139.04

Source: Energy Information Administration (EIA), Electric Power Annual 1999 Volume II, DOE/EIA-0348(99)/2, (October 2000), (Table A3).

http://www.eia.doe.gov/cneaf/electricity/epav2/html_tables/epav2ta3p2.html

Notes:

[1]Uncontrolled sulfur dioxide emission factors. "x S" indicates that the constant must be multiplied by the percentage (by weight) of sulfur in the fuel. Sulfur dioxide emission estimates from facilities with flue gas desulfurization equipment are calculated by multiplying uncontrolled emission estimates by one minus the reported sulfur removal efficiencies. Sulfur dioxide emission factors also account for small quantities of sulfur trioxide and gaseous sulfates.

[2]Parenthetic values are for wet bottom boilers; otherwise dry bottom boilers. If bottom type is unknown, dry bottom is assumed. Emission factors are for boilers with a gross heat rate of 100 million Btu per hour or greater.

[3]Uncontrolled carbon dioxide emission estimates are reduced by 1% to account for unburned carbon.

[4]Sulfur dioxide emission estimates from fluidized bed boilers assume a sulfur removal efficiency of 90%.

[5]Emission factors for petroleum coke are assumed to be the same as those for anthracite. If the sulfur content of petroleum coke is unknown, a 6 percent sulfur content is assumed.

[6]Oil types are categorized by Btu content as follows: heavy (greater than or equal to 144,190 Btu per gallon), and light (less than 144,190 Btu per gallon). cf = Cubic Feet. gal = U.S. Gallons. lbs = Pounds.

Table 12.4 - Global Warming Potentials (GWP)

(100-year time horizon)

Gas	GWP
Carbon dioxide (CO2)	1
Methane (CH4)*	21
Nitrous oxide (N2O)	310
HFC-23	11,700
HFC-125	2,800
HFC-134a	1,300
HFC-143a	3,800
HFC-152a	140
HFC-227ea	2,900
HFC-236fa	6,300
HFC-4310mee	1,300
CF4	6,500
C2F6	9,200
C4F10	7,000
C6F14	7,400
SF6	23,900

Source: EPA, Executive Summary of the 2001 Inventory of U.S. Greenhouse Gas Emissions and Sinks, Global Warming Potentials, EPA 236-R-01-001 (April 2001), http://www.epa.gov/globalwarming/emissions/national/gwp.html, TABLE or PAGE???

[1]The methane GWP includes direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO2 is not included.

The GWP of a greenhouse gas is the ratio of global warming, or radiative forcing – both direct and indirect – from one unit mass of a greenhouse gas to that of one unit mass of carbon dioxide over a period of time.

Table 12.5 - Approximate Heat Content of Selected Fuels for Electric Power Generation

Fossil Fuels [1]	
Residual Oil (million Btu per barrel)	6.287
Distallate Oil (million Btu per barrel)	5.825
Natural Gas (Btu per million cubic ft)	1,019
Coal (million Btu per Short Ton)	20.479
Biomass Materials [2]	
Switchgrass Btu per pound	7,341
Bagasse, Btu per pound	6,065
Rice Hulls, Btu per pound	6,575
Poultry Litter, Btu per pound	6,187
Solid wood waste, Btu per pound	6-8,000

Sources

1. EIA, Annual Energy Outlook, DOE/EIA-0384(00) (Washington, D.C., August 2001), Appendix ii
2. Animal Waste Screening Study, Electrotek Concepts, Inc., Arlington, Va. June 2001.

Table 12.6 - Approximate Heat Rates for Electricity

(Btu per Kilowatthour)

	1980	1990	1999	2000	2010	2020
Fossil-Fueled Steam-Electric Plants[1]	10388	10402	10346	10346		
Nuclear Steam-Electric Plants	10908	10680	10623	10623		
Geothermal Energy Plants[2]	21639	21096	21017	21017		

Source: EIA, *Annual Energy Review*, DOE/EIA-0384(00) (Washington, D.C., August 2001), Table A6

Notes:

[1] Used as the thermal conversion factor for hydroelectric power generation, and for wood and waste, wind and solar energy consumed for the generation of electricity.

[2] Used as the thermal conversion factor for geothermal energy consumed for the generation of electricity

Table 12.7 - Heating Degree Days by Month

	1980	1990	1999	2000	2010	2020	Normal[1]
January	887	728	861	879			948
February	831	655	647	636			768
March	680	535	645	493			611
April	338	321	319	345			339
May	142	184	139	121			150
June	49	29	31	34			36
July	5	6	5	5			7
August	10	10	12	6			13
September	54	56	62	85			69
October	316	246	275	246			271
November	564	457	413	611			528
December	831	789	760	999			836
Total	4707	4016	4169	4460			4576

Source: EIA, *Annual Energy Review 2000,* DOE/EIA-0384 (00) (Washington, D.C., August 2001), Table 1.7

Notes:

[1] Based on calculations of data from 1961-1990

Table 12.8 - Cooling Degree Days by Month

	1980	1990	1999	2000	2010	2020	Normal[1]
January	9	15	12	6			7
February	4	14	11	8			7
March	13	21	12	20			16
April	23	29	40	31			31
May	95	86	94	131			95
June	199	234	219	221			208
July	374	316	374	293			317
August	347	291	305	299			287
September	192	172	152	167			154
October	42	57	55	54			52
November	10	16	17	11			13
December	5	9	6	4			7
Total	1313	1260	1297	1245			1193

Source: EIA, *Annual Energy Review 2000,* DOE/EIA-0384 (00) (Washington, D.C., August 2001), Table 1.7

Notes:

[1] Based on calculations of data from 1961-1990